

Students and their choosing of computing: findings from the 'why computing' project

Payne, L.

Unpublished report deposited in CURVE October 2014

Original citation & hyperlink:

Payne, L. (2014) Students and their choosing of computing: findings from the 'why computing' project. Coventry: Coventry University.

Additional information : The PhD thesis which this report refers to is also available from Curve: <https://curve.coventry.ac.uk/open/items/e0ea7a3b-9a34-43e3-9018-582d56b3154e/1/>.

Copyright © and Moral Rights are retained by the author(s) and/ or other copyright owners. A copy can be downloaded for personal non-commercial research or study, without prior permission or charge. This item cannot be reproduced or quoted extensively from without first obtaining permission in writing from the copyright holder(s). The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the copyright holders.

CURVE is the Institutional Repository for Coventry University
<http://curve.coventry.ac.uk/open>

Students and their choosing of Computing:
Findings from the '*Why Computing?*' project

Lisa Payne, Coventry University

September 2014

Dr Lisa Payne
Department of Computing
Coventry University
email: l.payne@coventry.ac.uk

© Lisa Payne, Coventry University 2014 [release v2]

This report is available via <<http://tinyurl.com/PaynePhDReport2013>>

Executive summary

Background

The '*Why Computing?*' project was an extended PhD research study set up to investigate how students decide whether or not to apply for a computing degree. This was based on concerns about students' motivation and knowledge. The work led to the consideration of student engagement as well as the IT skills shortage.

Main findings

The major findings of this project were:

- The geeky public image does not reflect much of the modern IT profession. This deters people with the broader range of skills needed for the range of IT roles. Careers advice sometimes lacks the necessary subtlety in this regard.
- There is a widespread lack of understanding as to the nature and substance of computing. It is often conflated with ICT and assumed to be about the usage of pre-existing IT systems. The fundamental task of computing, of developing new IT systems and novel technologies, is largely unrecognized by the public. The public conflation of Computing and ICT means that the credibility and worthiness of Computing as an academic subject and degree is unknown and sometimes challenged. It also means that students sometimes enrol on a degree in Computing expecting it to be akin to their A-level ICT.
- Few pupils currently (pre-September 2014) get the opportunity to study Computing at school. Partially as a consequence, those young people who do have a good understanding of the nature of Computing have most often acquired this through a parent or other relative who works in IT.
- Changes in the National Curriculum, to present Computing rather than ICT, will help with broadening public understanding of the nature of Computing. Whilst there are several initiatives to increase the scope and depth of technical expertise in schools, currently there is a severe shortage. This may lead to a significant proportion of pupils having a poor, or even demotivating, experience of Computing, with negative long-term potential consequences for recruitment.
- Students often relish opportunities for flexibility or creativity in their studies.
- There are a number of factors contributing to the conundrum of there being both elevated Computing graduate unemployment and an IT skills shortage. One factor is that any degree can expose students to only a limited range of the current IT technologies. Therefore the expertise of any particular graduate will not meet the specific requirements of some, or perhaps many, employers.

Recommendations

These findings led to a number of recommendations to Government, other policy makers, professional bodies and schools as well as to universities and employers. They are presented in the final section, grouped by stakeholder.

1. INTRODUCTION

1.1 Background and motivation

The '*Why Computing?*' project emanated from two main concerns about university computing students¹. Computing consistently has one of the poorest graduate employment rates² and yet IT employers complain that they cannot find suitable recruits. Why is this? Secondly, experience over decades of teaching indicated that some students are very surprised by core aspects of their course. Additionally, a sizeable minority of computing students do not seem to enjoy any aspect of their course and yet seem to be unable to say what they would prefer. So why are these students there? What were the social processes which led them to enrol? By understanding these issues it ought to be possible to make changes which would help to ensure that those students who do enrol on a computing degree better understand what it is about. Such students are more likely to enjoy their course and engage fully with it. They are more likely to benefit fully from their experience and develop into strong graduates. The findings of this project led to recommendations to many stakeholders concerned with developing young people into employable computing graduates.

Alongside these prime concerns, computing has a very low level of female participation both in education and employment. Whilst this has been subject to much research, and many initiatives, female participation continues to decline. Additionally, Computing as an HE (Higher Education) discipline has amongst the poorest levels of graduate employment² and student satisfaction³.

This project was undertaken in a period during which such issues became politically prominent. The NESTA report⁴ into the labour supply for the creative industries pointed to the dearth of technical computing (particularly computer

¹ The word 'student' is used to refer to learners studying at Higher Education level, typically at university. For clarity, younger learners, typically studying at school or college, are referred to as 'pupils'.

² 14% of computing 2012 graduates were unemployed six months later, as compared with an average of 8%. Source: HESA (2013) *Destination of Leavers from Higher Education in the United Kingdom for the Academic Year 2011/12*. Higher Education Statistics Agency. [online] Available from <http://www.hesa.ac.uk/index.php?option=com_content&task=view&id=2903&Itemid=161>

³ An analysis of the 2011 National Student Survey (NSS) results showed that only 77.9% of computing students were satisfied with their course, as compared with 83.3% generally. Source: HEA (2012) *Computing: National Student Survey Discipline Report*. Higher Education Academy. [online] Available from <https://www.heacademy.ac.uk/sites/default/files/resources/COMPUTING_NSS_Discipline_Report.pdf>

⁴ NESTA (2011) *Next Gen: Transforming the UK into the world's leading talent hub for the video games and visual effects industries*. A review by Ian Livingstone and Alex Hope for NESTA (National Endowment for Science, Technology and the Arts). [online] Available from <http://www.nesta.org.uk/home1/assets/features/next_gen> Commissioned by the DCMS (Department for Culture, Media and Sport).

programming) in British schools. Alongside this the Royal Society⁵ investigated the state of computing in UK schools. These reports both received much publicity; both challenging the computing existing curriculum in UK schools. The only 'computing' currently experienced by most school pupils is the subject of ICT (Information and Communication Technology). Whilst a recent OFSTED report⁶ identified much good practice in its teaching, and many pupils enjoy their ICT lessons⁷, the subject nonetheless acquired an image as being boring, pointless or poorly taught^{8 9}. Computing At School (CAS)¹⁰, a campaign group supported by the BCS (British Computer Society), with members from industry and across education, pressed for change.

The DfE (Department for Education) has responded to this situation with changes to the National Curriculum which take effect from September 2014. The prime change is to refocus teaching in the discipline of computing from ICT into a new core subject, Computing. This change will be useful, giving all school pupils exposure to key ideas in technical computing. However, as will be explored later, there is a real risk that the current plans will generate a situation which is more (not less) problematic for schools, universities and employers, and hence UK industry.

1.2 The 'Why Computing?' project

The 'Why Computing?' project was an extended PhD study, funded by Coventry University¹¹. Its core objective was to investigate the influences on young people, on how they perceive computing and why they choose (or reject) it. The project included 61 computing students, prospective students and computing academics. There were over 100 hours of one-to-one interviews and focus groups, supported

⁵ Royal Society (2012) *Shut down or restart? The way forward for computing in UK schools*. Royal Society. 13 January 2012. [online] Available from <<http://royalsociety.org/education/policy/computing-in-schools/report/>>

⁶ OFSTED (2011) *ICT in schools 2008-11*. Office for Standards in Education, Children's Services and Skills (OFSTED). December 2011 [online] Available from <[http://www.ofsted.gov.uk/sites/default/files/documents/surveys-and-good-practice/i/ICT in schools 2008-2011.pdf](http://www.ofsted.gov.uk/sites/default/files/documents/surveys-and-good-practice/i/ICT%20in%20schools%202008-2011.pdf)>

⁷ BCS (2005) *Attitudes of girls aged 13-17 to a Career in IT*. Summary Research Report. British Computer Society. 25 May 2005. [online] Available from <<http://www.bcs.org/upload/pdf/girlsandit.pdf>>

⁸ CPHC (2006) *Investigations into the decline in BSc Computing / IT Applications to British Universities*. By Anna Round commissioned by the Council of Professors and Heads of Computing (CPHC). [online] Available from <<http://cphcuk.files.wordpress.com/2014/01/cphc-admissions-trends-report.pdf>>

⁹ Anstead, D. (2010) 'Taking the C (out of ICT)'. *Naace Annual Strategic Conference 2010*. Held 16-18 March 2010 at Blackpool, England. [online] Available from <http://www.northerngrid.org/attachments/722_david_anstead_naace_2010.pdf>

¹⁰ <http://www.computingatschool.org.uk/>

¹¹ The academic thesis 'Why do students choose computing?: influences, perceptions and engagement' is available from <<http://tinyurl.com/PaynePhD2013>> and contains more detail and supporting evidence. It also contains additional findings related to the specific research methods adopted.

by other forms of data collection, such as questionnaires, generating over 200 data items overall. Some participants remained in the study for up to 18 months, contributing their developing views over that period.

1.3 Audience

This report has been written to disseminate the main findings of the project, to stakeholders in computing education, including those outside the academic community. The project identified, or provided confirmation of, a number of issues and a number of recommendations are made to address them, at least in part.

1.4 Terminology

The use of terminology, such as computing and IT, is far from consistent and is part of the source of the issues identified by this project. Even within England terms are used in different ways by different stakeholder groups. However there are some essential distinctions which must be made. To this end, in this report terms have been used as described in the box, below. These distinctions broadly align with those adopted by the Royal Society in their recent report⁵.

computing (lower case 'c'):	the entire discipline area
Computing (upper case 'C'):	a course title
technical computing	those aspects of computing which require precision and logic (including, but not limited to, computer programming). Degree courses which focus on this sort of activity may be entitled Computer Science, Computing or Software Engineering: they are focussed around the development of computer systems.
ICT:	the school subject, which often focusses solely on the uses of existing systems (although the National Curriculum does also permit work of a development nature).
IT:	<ul style="list-style-type: none">• computing activity within employment, whether in a company whose prime purpose is computing or in a support role within some other industry.• usage of existing computing systems.• a course title: one which covers system usage (rather than development) and may have a business focus.• sometimes used to refer to the entire discipline (eg BCS: The Chartered Institute for IT).

1.5 Report Structure

This report contains sections on issues relating to school computing, university computing and then the employment of computing graduates. However the first section deals with the image of computing: the public's awareness of the nature of computing. The report culminates by presenting, together, all the recommendations. Throughout sample, anonymised, participant quotations are provided by way of illustration.

2. AWARENESS OF THE NATURE OF COMPUTING

2.1 A geeky image

The IT industry suffers from an image problem which is widely recognised. The geek stereotype is routinely reinforced in the media¹². Whilst this image might reflect some of the people working in computing it will influence who is attracted to it. Generally, the geeky image is recognised as being a deterrent^{13 14 15 16}. By contrast, participants in this project often saw 'geek' as a gentle form of abuse – although these were perhaps atypical young people who, for whatever reason, were already interested in or involved in computing. Some participants saw that the term can be positive:

"Geekiness isn't a negative word. It depends on the way that you perceive it. In an industry like computing, 'geeky' is a very good one" (Justin)¹⁷.

There are reports^{18 19} that some people are attracted to computing by its image – that 'geek' has become 'chic'. Whilst the geek stereotype may support a group

¹² The term 'geek' is seldom defined in research but is used to refer to people who are asocial, overweight, greasy and male (Woratschek and Lenox 2009); male, anti-social and hardware-focussed (Lang 2012) or obsessive (Bell and Corner 2011). *Sources:* Woratschek and Lenox 2009 (see footnote #13); Lang, C. (2012) 'Sequential Attrition of Secondary School Student Interest in IT Courses and Careers'. *Information Technology and People*. 25(3), 281-299; Bell and Corner 2011 (see footnote #18).

¹³ Woratschek, C. and Lenox, T. (2009) 'Student Attitudes and Perceptions Regarding Computing and its Related Disciplines'. *Information Systems Education Journal*. 7(58), 3-22

¹⁴ Mitchell, A. (2005) 'Computing Science: What do pupils think?' *HEA-ICS workshop*. Held 25 January 2005 at Napier University, Edinburgh. [online] Available from <[http://www.ics.heacademy.ac.uk/student_retention/workshops/pres/Alison Mitchell.ppt](http://www.ics.heacademy.ac.uk/student_retention/workshops/pres/Alison%20Mitchell.ppt)>

¹⁵ Ash, R.A., Coder, L., Dupont, B. and Rosenbloom, J.L. (2009) 'Examining the obstacles to broadening participation in computing: Evidence from a survey of professional workers'. *Contemporary Economic Policy*. 27(3), 413-421

¹⁶ Pau, R., Argles, D., White, S. and Lovegrove, G. (2004) *Computer Geek Versus Computer Chic: IT Education and IT Careers*. Southampton: Southampton University. 1-15

¹⁷ Throughout, participants' names have been replaced by pseudonyms

¹⁸ Bell, A. and Corner, A. (2011) 'Specsaviours'. *Times Higher Education*. 25 August 2011, 36-38

¹⁹ Knuth, D. (2011) *The Art of Programming*. Interview for BCS, June 2011. [online] Available from <<http://www.bcs.org/content/conWebDoc/40462>>

identity or bonding^{18 20}, this project did not identify a single participant who would actually choose to identify themselves as a geek. However some participants recognised that other people may see them as such and were clearly pleased to have their skills and dedication acknowledged.

"I never really saw myself as one even though I probably am... [a geek]. I tell you a lot of people [i.e. students] probably think that. It's like well: "Yeah [computing students] are generally geeks but, well I'm not really" " (Michael).

"I recognise it [i.e. the geek stereotype] and I think I was possibly part of it at one point [...] You get up and I'd go downstairs into my backroom and spend the whole day there and have to surface for meals every so often but that was about it really" (Martin).

Thus, whilst the geek stereotype may have some basis in reality it is vital that it is challenged and modified if IT is to attract a broader range of people. Only by moderating its image will IT be able to attract those who are currently being deterred (see Recommendation #1).

2.2 Who works in IT?

In general, project participants, even computing HE students, had surprisingly little awareness of IT employment opportunities or the sorts of people employed in IT²¹. Most, although not everyone, was aware that IT offers opportunities which are well-paid.

"I think everyone seems to have this thing, outside of knowing anything about it, that you'll get a lot of money" (Carl).

Although some studies¹⁴ report that school pupils believe other professions are better paid, this is not necessarily a contradiction. Some participants were aware of the male-biased gender profile, John reporting that a female friend had made an alternative career choice as a direct consequence. Evidence of such alienation is widespread²² in the research into the gender balance. A few participants were aware that many job advertisements request prior experience.

²⁰ Hewner, M. and Knobelsdorf, M. (2008) 'Understanding Computing Stereotypes with Self-Categorization Theory'. In *Proceedings of 'Koli Calling' International Conference on Computer Science Education*. Held 13-16 November 2008 at Koli, Finland, 72-75 [online] Available at <<http://www.it.uu.se/research/publications/reports/2009-004/2009-004.pdf#page=76>>

²¹ This is surprising since they were all people who had at least expressed an interest in computing as a career route, although those participants who were computing students were mostly in the early months of their studies.

²² Including, Margolis, J. and Fisher, A. (2002) *Unlocking the clubhouse: women in computing*. Cambridge, MA: MIT; Singh, K., Allen, K.R., Scheckler, R. and Darlington, L. (2007) 'Women in computer-related majors: a critical synthesis of research and theory from 1994 to 2005'. *Review of Educational Research*. 77(4), 500-533; Griffiths, M. and Richardson, H. (2010) 'Against all odds, from all-girls schools to all-boys workplaces: women's unsuspecting trajectory into the UK ICT sector'. In *Gender Issues in Learning and Working with Information Technology*. ed. by Booth S., Goodman S. and Kirkup G. Hershey, PA: IGI Global, 99-112; Computer Weekly (2012) 'Men and women disagree on reasons why IT is less attractive to women'. *Computer Weekly*. 12 July 2012. [online] Available from <<http://www.computerweekly.com/news/2240159441/Men-and-women-disagree-on-reasons-why-IT-is-less-attractive-to-women>>; Nielsen, S., von Hellens, L., Beekhuyzen,

"The people who dominate [employment] are still the older people. [Employers] see experience as better" (Michael).

They interpret advertisements for jobs which require experience as implying that older employees dominate. (This is in line with a survey of computer professionals which found that some people felt they had been discriminated against because they were too young²³.) The reality is that IT still has a relatively youthful, although ageing, profile^{24 25}.

In direct contrast to the asocial, geeky stereotype of IT, some participants were aware that social skills are important in computing and required for many roles.

"Before, when computing was quite new, you could be quite unsociable because you were focussed on one task. But since computing is next to business, I'd say you have to have that sociable side: you have to interact with customers, talk to them and get to know them" (Omar).

However careers advice sometimes can sometimes suggest otherwise²⁶. Some participants believe that IT employers might provide say, network spaces in the workplace, since they wish to develop the social skills of their staff in order that they can be more productive.

"If it's just you, programming, then you kind of lose your social skills if you do it for like long periods of times" (Victoria).

A broader understanding of the opportunities for social interaction, indeed that some IT roles require well-developed social skills, would help to broaden the appeal of IT careers and would reduce a source of deterrence, perhaps particularly for some women^{13 27}. Hence efforts to modify the image of IT must encompass the professional and interactional skills which many roles draw on. (See Recommendations #1, 2, 8, 19.)

J. and Trauth, E. (2003) 'Women Talking About IT Work: Duality or Dualism'. *ACM SIGMIS Conference '03*. Held 10-12 April at Philadelphia, PA. 68-74

²³ Computer Weekly (2006) 'Our industry is the worst for age discrimination, say IT professionals'. *Computer Weekly*. 12 October 2006. [online] Available from <<http://www.computerweekly.com/news/2240078694/Our-industry-is-the-worst-for-age-discrimination-say-IT-professionals>>

²⁴ In 2011 workers in the IT industries were aged 39 on average, compared with 41 in the workforce generally, with 19% being aged under 30. Source: ONS Labour Force Survey. [online] Available from <<http://www.ons.gov.uk>>

²⁵ e-SkillsUK (2012) *Technology Insights 2012*. e-Skills UK Sector Skills Council. July 2012. [online] Available from <http://www.e-Skills.com/Documents/Research/Insights-2012/TechnologyInsights_2012_UK.pdf>

²⁶ Lounsbury, J.W., Moffitt, L., Gibson, L.W., Drost, A.W. and Stevens, M. (2007) 'An Investigation of Personality Traits in Relation to Job and Career Satisfaction on Information Technology Professionals'. *Journal of Information Technology*. 22(2), 174-183

²⁷ von Hellens, L., Clayton, K., Beekhuyzen, J. and Nielsen, S. (2009) 'Perceptions of ICT Careers in German Schools: An Exploratory Study'. *Journal of Information Technology Education*. 8, 211-228

2.3 What is computing?

Many participants reported that 'outsiders' do not know what computing encompasses. As previous studies have reported^{14 28 29}, computing is regularly confused and conflated with ICT.

"I've said I'm doing computer science and people immediately assume it's ICT and thought it was really easy" (Martin).

Some research participants used 'computing' and 'ICT' as synonyms, not recognising their different foci. There are many reports^{14 30} of a lack of understanding of the substance of computing amongst school pupils, new university computing students and school teachers. This is evidently leading to pupils making misinformed subject and career choices, in both directions (see §3.3). Many participants spoke of fellow students who had been expecting their computing degree to be similar to their school ICT. Some spoke of friends who decided not to pursue computing into HE because they felt they already knew enough and could explore new facilities on an 'as needs' basis, implying that they saw it as ICT.

As already mentioned the public image of computing and IT employment needs changing but there would also be benefits if the public was more aware of the nature and substance of computing (Recommendations #2, 15, 19).

2.4 Is it credible?

The widespread lack of understanding as to the substance of computing is not only leading to misinformed choices but computing is sometimes⁸ even seen as lacking credibility as an academic subject. The Royal Society⁵ was very clear as to the rigorous, academic nature of computing as a subject. Victoria reported how a friend had been told by her father that she should not apply for computing as it was not worthy of study at university but could be studied in her own time and Michael reported how he had been teased that his computing degree was a 'doss degree'. Improving awareness as to the nature of computing, as already discussed, would improve this situation. The phasing in of the revised National Curriculum will help broaden appreciation.

²⁸ Lovegrove, G. and Round, A. (2005) *IT Professional in Education: Increasing the Supply*. A Report on the North-East regional meeting of the HEFCE-funded initiative. Held 8 November 2005 at Newcastle, England. [online] Available from <<http://www.bcs.org/upload/pdf/itprofnewcastle.pdf>>

²⁹ For example, CPHC (2009) *A Response to the Interim "Digital Britain Report"*. Council of Professors and Heads of Computing. By L. MacKinnon. [online] Available from <<http://cphcuk.files.wordpress.com/2014/01/cphc-db-response.pdf>>; McChesney, I. and Alexander, S. (2006) 'Understanding and Influencing Pre-entry Perceptions of Computer Science'. In *Proceedings of Informatics Education Europe*. Held 9-10 November 2006 at Montpellier, France. [online] Available from <http://www.ics.heacademy.ac.uk/education_europe/Session_4/26_Sylvia_Alexander.doc>

³⁰ Cutts, Q., Brown, M., Kemp, L. and Matheson, C. (2007) 'Enthusing and Informing Potential Computer Science Students and their teachers'. *ITiCSE '07*. Held 23-27 June 2007 at Dundee, Scotland

2.5 Is it creative?

In exploring the character of computing its practical nature, the need for meticulous care and rigour and the qualities of logic and patterns were raised, as were the routine nature of some tasks, the excitement and sense of achievement. That participants raised these as fundamental qualities of the subject was unsurprising. However many participants also commented on the creativity of computing whereas previous studies^{8 28} have reported the apparent lack of creativity as being a potential deterrent. The term 'creative' has two distinct interpretations of 'imaginative' and 'productive' but studies are not always careful to make this distinction. Many participants in this project were clear that they saw computing as providing an opportunity both to exercise their imagination and to be innovative. The potential tension with IT employment is discussed later (§4.3).

3. COMPUTING IN SCHOOLS

3.1 The National Curriculum, past and new

Until September 2014 the National Curriculum requirements for state maintained schools in England included ICT as a core subject up to age 14 and a compulsory foundation subject for ages 14-16³¹. ICT was also widely available as a GCSE³² and A-level³³ qualification³⁴. As described earlier (§1.1) ICT has a mixed reputation. As a qualification subject it is popular, being taken by many pupils, but it has a reputation for not being very challenging and not very useful. Whilst the curriculum did allow schools to deliver some classical computing content, such as algorithms and programming, most pupils did not experience this but rather a delivery which dealt with the usage of, mostly business-related, software. Whilst skills in such matters are important for much contemporary employment they do not introduce pupils to the nature and substance of Computing.

Most pupils did not get an opportunity to study Computing at school. In recent years only about 10% of schools^{35 36} offered it at A-level. At GCSE it was introduced for delivery in 2010, although the uptake is currently still very small,

³¹ DfE (2012) *About the school curriculum: What is statutory?* Updated 5 July 2012. [online] Available from <<http://www.education.gov.uk/schools/teachingandlearning/curriculum/b00200366/about-the-school-curriculum/what-is-statutory>>

³² General Certificate of Secondary Education, typically taken at age 16

³³ Typically taken at age 18

³⁴ There is also a range of equivalent vocational qualifications in ICT.

³⁵ Estimated: based on 4000 entrants in 2011, spread over c4000 secondary schools, with an average class size of say 10 pupils. There was a similar number of entrants in 2014. *Source*: JCQ (see footnote #36). However in 2001 there were over 21,000 entrants. *Source*: Royal Society (see footnote #5).

³⁶ JCQ (Joint Council for Qualifications) [online] Available from <<http://www.jcq.org.uk/examination-results/a-levels>>

with 16,000³⁷ pupils being examined in 2014³⁶ in Computing. Qualifications at this level are not entirely novel. Through the 1970's and 1980's GCE O-level³⁸, and later GCSE, qualifications were available in Computer Studies^{5 39}. (Over time this was replaced by IT and then evolving into the familiar ICT curriculum.)

Of course, as mentioned earlier (§1.1), the curriculum in schools is in the process of changing. From September 2014 the teaching that pupils will experience, in both primary and secondary maintained schools, will focus on Computing, rather than ICT. From early years⁴⁰ teaching, pupils will be exposed to key concepts in Computing, such as the creation of an algorithm to solve a problem, for example.

3.2 Consequences of changes in the curriculum

The changes to the National Curriculum⁴¹ are sometimes presented as though they were merely a refocussing of delivery. However for most schools they represent a radical change. The rationale for teaching technical Computing to all pupils is to both increase the quality and supply of potential IT employees and to encourage computational thinking across the workforce. However there will be a number of consequences.

Firstly, ICT skills will be taught in schools much less, including skills which many employers seek, such as the advanced use of business software. The new curriculum probably will facilitate the development of basic computer literacy skills but it is not clear if pupils will continue to develop skills such as webpage development or file hierarchy management.

Secondly, some schools are struggling to deliver the curriculum owing to a dearth of suitable Computing expertise⁴². The 2010 DfE Schools Workforce Census⁵ found that of 18,400 secondary teachers of ICT in England only 35% (6,440) were qualified⁴³ in either a computing⁴⁴ or a mathematical subject. (The relevance of

³⁷ Compared with 760,000 in Mathematics, for instance.

³⁸ General Certificate of Education. O-levels were typically taken at age 16. They were replaced by GCSEs.

³⁹ Clark, M. and Boyle, R. (2006) 'Computer Science in English high schools: we lost the S, now the C is going'. *Lecture Notes in Computer Science #4226 'Informatics Education'*. 83-89 [online] Available from <http://pdf.aminer.org/000/450/138/computer_science_in_english_high_schools_we_lost_the_s.pdf>

⁴⁰ Key Stage 1, age 5-7

⁴¹ <https://www.gov.uk/government/publications/national-curriculum-in-england-computing-programmes-of-study>

⁴² A number of sources have reported that in 2010 "only 3 of the 28,767 people awarded QTS (*Qualified Teacher Status*) in 2010 had a degree in Computing." This is based on a misinterpretation of a statement in the NESTA report (p39) (see footnote #4) which actually refers to the subject identified by new teachers when they registered with the General Teaching Council (GTC). A full account of this misinterpretation is available elsewhere (see footnote #11, Appendix F).

⁴³ Qualified in that they hold a degree or that their teacher-training qualification specialisation was in the subject.

mathematics here is open to some debate⁴⁵, although it does imply a facility with logic and rigour.) However neither a mathematics nor an ICT qualification would necessarily suggest that a teacher could readily deliver the new Computing curriculum. However even the most inclusive interpretation of this data indicates that there is on average only 1.5 'qualified' teachers per school. Indeed the DfE survey showed that 21% of secondary schools had no staff with any such qualification. The situation in primary schools is also problematic. Whilst the technical skills required to teach Computing in primary schools are less than in secondary, it is usual for every primary teacher to deliver all subjects. If this model is retained then providing the training, and confidence building, needs of primary teachers represents a significant challenge.

There are a number of very welcome initiatives to address this skills shortage. Bursaries and scholarships have been made available to encourage computing graduates to enter teaching and CPD opportunities are available for existing teachers. CAS/BCS (funded by the DfE) has developed a network of Master Teachers to support and develop teachers in their locale and the BCS has set up an accreditation scheme for teachers of computing.

If all teachers are to deliver the curriculum in an engaging, exciting and confident manner there is a huge challenge remaining. The Royal Society in their request for curriculum change went so far as to say that Computing should not be a statutory requirement until sufficient specialist teachers were in post⁴⁶. Unfortunately the changes were introduced with little over a year's warning which is far too little for something so radical. Schools will endeavour to deliver what they believe the curriculum requires but where there is little local expertise in, and confidence with, technical computing the danger is that pupils will be exposed to concepts in a way which is dull, mechanistic or off-putting. This could herald a return to 1990 when Her Majesty's Inspectors⁴⁷ (HMI)⁴⁸ concluded that: "*the study of Computing can and should be stimulating and fascinating for pupils. As experienced by many, it is sometimes dry, dull and unexciting*". If this becomes the reality for many pupils the curriculum changes would be an opportunity lost. (See Recommendations #16, 17, 18.)

3.3 Exposure to computing: the role of parents

One effect of exposing all pupils to technical computing content is that they should get a better understanding of what Computing is about and what it entails. As mentioned earlier (§2.3), at the moment some pupils assume Computing is ICT

⁴⁴ Although the breakdown is not known, the likelihood is that a sizeable proportion of these have an ICT specialisation in their teaching qualification as this has been a popular route into teaching for business graduates.

⁴⁵ Discussed further, later (§4.1)

⁴⁶ Royal Society (2010) (p10, Recommendation #6) (see footnote #5)

⁴⁷ A precursor of OFSTED: the school inspectorate

⁴⁸ HMI (1990) *Computing as a specialist subject in schools and sixth form colleges, 1987-1989*. Inspectorate of Schools. Series 175/90/NS. London: Department of Education and Science

and make their course choices on that basis. The result is that perhaps they reject something which they would enjoy or, potentially more problematically, select a subject which does not really suit them.

Currently a few pupils do get interested in computing topics through school. This might be through taking a Computing qualification at one of those few schools where they are available (see §3.1). Alternatively some schools included some programming or computer control, for instance, within their ICT delivery or elsewhere (see §3.1). However these were uncommon experience, even amongst the atypical group of young people who participated in this project. Most of the participants who had reasonable understanding of what Computing is about had gained this through influences at home, usually from a parent, or other relative, who works in IT.

"Parents pushed me to study Computer Science instead of IT or Business ICT" (Victoria).

"He [his uncle, who works in software development] said: 'we use a lot of maths, and use a lot of logic work, teamwork, socialisation and stuff like that.' I thought: 'well that's the sort of field I'd like to go into'" (John).

The changed curriculum will thus allow many more pupils to experience technical Computing, to understand its nature and purpose, and to decide from a firmer basis whether they want to pursue it further. However, as discussed (§3.2), there is a potential danger that its appeal may diminish. The quality of pupils' experiences in schools will affect whether pupils are attracted into the industry. It is thus crucial that schools are supported and encouraged where possible to deliver the curriculum in an engaging and dynamic manner.

4. COMPUTING IN UNIVERSITIES

4.1 University⁴⁹ entrance

Having, by whatever means, interested pupils in applying to study a computing degree appropriate pupils need to be admitted. A number of issues emerged in this regard.

Computing degrees do not require A-level Computing for entry. There are at least three reasons for this. Firstly only 4,000⁵⁰ pupils take this qualification, but around 10,000⁵¹ UK students gain admission to computing degrees each year. Secondly, some universities see little benefit in pupils having this qualification⁵². Finally, a

⁴⁹ This is not intended to exclude other HE providers, such as HE in FE

⁵⁰ JCQ data (see footnote #36)

⁵¹ UCAS data. Source: Royal Society (2010) (see footnote #5)

⁵² Clark, M. and Boyle, R. (2005) 'The Transition from School to University: Would Prior Study of Computing Help?' In: 'From Computer Literacy to Informatics Fundamentals'. In *Proceedings of the International Conference on Informatics in Secondary Schools - Evolution and Perspectives (ISSEP*

number of universities do require A-level Mathematics. Some Computer Science degree courses (probably a small minority) are essentially courses in applied mathematics and students on such courses need to be mathematically adept. However many computing degrees are not mathematically focussed. Some of these include elements (perhaps modules) which explore the mathematical fundamentals of, say, algorithms for which students need to be mathematically confident. For many of these degrees A-level Mathematics is not directly relevant⁵³.

For most computing degrees entrants require only GCSE Grade 'C' Mathematics (not A-level)⁵ and a number of students struggle with the mathematical aspects of their course, even where these are very modest indeed. The students who struggle may tend to be those with poorer Mathematics qualifications. It may be worth some institutions investigating this (see Recommendation #6). However, raising this as a concern is not entirely about students' mathematical competence *per se*. Computing students need to be able to work logically and handle abstract concepts, rigorously. This is crucial for many technical computing tasks including, but not limited to, programming, and important for more creative and business-focussed computing activities too.

4.2 Course content

Even if a student has an appropriate background and the capability to succeed, a computing degree may not be quite what they expect. As explained (§2.3), many pupils do not know what computing may comprise and assume it to be a follow-on from ICT and, even if they know that it will be somewhat different, they may not appreciate what the subject is, or is like⁵⁴.

A broad range of computing degree titles is offered. As well as 'mainstream' titles such as Computing and Computer Science there are many specialist routes such as Software Engineering, business-related courses and those with a more creative focus, such as Games Technology. However computing degrees are widely varying, in ways not necessarily conveyed by their title. Although all computing courses (probably) conform to the QAA Subject Benchmark Statement⁵⁵, even amongst those courses entitled Computer Science: *"it is very hard to identify*

2005). Held 30 March–1 April 2005 at Klagenfurt, Austria. 'Lecture Notes in Computer Science' 3422 Springer

⁵³ However if a student has A-level Mathematics it does indicate that they can work rigorously and logically and handle abstract concepts.

⁵⁴ To an extent this must apply to most, if not all, academic disciplines. Does a History student know how degree level study differs from their A-level? or a Mathematics student? Of course there are summer schools and open days and similar opportunities offered to help bridge such gaps. However for computing, the consequences of a lack of understanding may have very significant consequences for the individual.

⁵⁵ QAA (2007) *Subject Benchmark Statement: Computing*. Quality Assurance Agency. 2nd edn. [online] Available from <<http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/computing07.pdf>>

*syllabus parts common to all programmes*⁵⁶. However, since computing degrees have varying aims and focus on different aspects of the subject, this would seem to be inevitable and is probably appropriate.

As a result of this diversity a student's pre-application investigation is particularly important. However it was notable how very little research many participants had undertaken in choosing a particular degree programme⁵⁷: indeed some were not even aware that universities derived their own curricula.

"Some of the modules that I've done in computing, it was completely different to what I think [sic] it would be. I mean things such as programming and software systems, I knew I'd be doing something along those lines. But then on the other hand, usability that was completely [unexpected]... and Maths [...] and what else – Computer Architecture [...] where we'd go through past history of [operating systems] and binary and just little things [...] It wasn't bad. It was quite interesting. I didn't think we'd be taught something like that at Computing" (Arthur).

However one or two participants commented that they had been unable to get the level of detail about course content that they wanted in order to inform their choice. Indeed some universities (or some courses) provide as little as a list of perhaps opaque module titles on their websites (see Recommendation #5).

Nonetheless many pupils clearly apply for computing degrees with limited or incorrect impressions of their nature or demands. Whilst not wishing to imply that institutions make course offers lightly nor that efforts are not already being made, it would probably benefit some students, and institutions, if even greater efforts were made to ensure that all successful applicants had a good appreciation of what they were applying for (see Recommendations #9, 12). In general, as far as possible, students should not be faced with surprises post-enrolment, particularly not unpleasant ones.

4.3 Creativity in computing

In terms of course content, a surprising feature was how positive participants generally were about the imaginative creativity of computing – and that in a subject which is often assumed to not offer it⁵⁸ (see §2.5).

"I mean to a point it is [...] routine but if I wasn't seeing something creative and imaginative, if I wasn't getting to use that part of my brain as well, I wouldn't do it" (Michael).

⁵⁶ Boyle, R., Carter, J., and Clark, M. (2002) 'What Makes them Succeed? Entry, Progression and Graduation in Computer Science'. *Journal of Further and Higher Education*. 26(1), 3-18

⁵⁷ Almost always they did actively choose their university though, but based on other criteria.

⁵⁸ Although not confined to Coventry University students this in part reflects the way that computing is being taught at Coventry, employing an active, project-based pedagogy. Such views were expressed by students on 'mainstream' computing courses, such as Computer Science, as well as those on more creatively focussed courses, such as Games Technology.

Some participants described being given a scenario and being asked to develop a solution. Generally they welcomed the freedom and flexibility in the requirements for their work.

"I think that's what I find most enjoyable about it, is you get that opportunity to explore things, you know, interests or something that you're not sure about, or you want to work more on and do that" (Carl).

However some participants were concerned by the open-endedness of tasks and were disconcerted by the lack of bounds on their efforts.

"Well how much do I put into it? How much do I keep going? It's quite hard" (Omar).

Course designers could consider if it were possible to incorporate bounded flexibility, particularly in student assessments (see Recommendation #7).

There is a tension here, which requires careful consideration. There are job roles in some IT sectors, where creativity and imagination are very important but in some roles the client's requirements dictate the work required with little, if any, scope for the individual's creativity. Students therefore need to understand this and probably need to experience it, as part of their degree, even if some of them may find it frustrating:

"you had to do... you had to work within the rules" (John).

4.4 Engagement

In investigating why some students did not seem to enjoy their course it was appropriate to consider student engagement with respect to issues beyond their expectations about course content *per se*. Some participants felt seriously demotivated by teaching which was at a level which mis-matched their needs. This was most evident in the teaching of mathematical aspects where some students need to be reminded of very basic concepts of arithmetic and others have strong A-level Mathematics. A student from Eastern Europe commented:

"The maths over here is very, very, very, very, very simple. It's very simple, yes. I've looked on the module, so there would be some more complicated stuff, like matrices and some differential equations, but they're still pretty easy" (Dee).

Course and module design must consider the needs of all students and derive ways so that students are not routinely asked to study material which is so unsuitable. (See Recommendation #14). At Coventry the move to project-based learning may mitigate the worst of this problem.

This scenario exemplifies the sort of reason which can lead some students to absent themselves from class. This project indicated that there is a risk of academics (or administrators) reacting inappropriately, and unhelpfully, if absenteeism is automatically taken as indicating that a student is disengaged. For example students can get very irritated by chasing which they feel is inappropriate:

"I went to one or two [lectures] afterwards, just so that they wouldn't ring me up again" (Pete).

This project indicated that there seem to be four 'dimensions' of engagement, with an individual student having some degree of each. These are intrinsic motivation (interest in their course and subject); extrinsic motivation (interested in the ultimate benefits which are anticipated); functional connectedness (as reflected in their behaviour including attendance); and emotional connectedness (how involved in their course they feel). By considering students against each of these four dimensions it may be possible to develop a more nuanced approach to encouraging engagement. For example, it may be appropriate to take steps to improve the sense of community and student belonging; or to ensure that students are clear as to the relevance of the material being taught, especially material they may struggle with. (See Recommendations #3, 4, 11).

Some institutions are unconcerned as to whether their students are engaged but rather focus on whether their students are actually learning⁵⁹ and, since learning is the overt *raison d'être* of a degree, this is appealing. It could be viewed that it does not matter how a student achieves their course's learning outcomes, as long as they do. However this view both ignores the other benefits of higher education, such as personal developmental, and could be risky. Many institutions feel the need to encourage students to engage, in the expectation that this will maximise their achievement.

5. COMPUTING GRADUATE EMPLOYMENT

5.1 Students' skills

Whilst various computing degrees have differing overall aims, some being quite narrow and specialist and others much broader, all need to provide students with practical skills, adequate for the target area of employment. (See Recommendation #10).

In some institutions⁶⁰ resource constraints are such that academics find it difficult or impossible to expose students to industrially relevant technologies. However some participants were very clear that they want, and for their employment prospects they believe that they need, skills in the most current technologies. (See Recommendation #13).

Whilst it is essential that students believe that they will be developing skills in technologies which will make them employable, some job advertisements are very specific. For example a recent advertisement for an unpaid internship specified:

⁵⁹ NAO (2007) *Staying the course: the retention of students in higher education: Report by the Comptroller and Auditor General*. National Audit Office. [online] Available from <http://www.nao.org.uk/publications/0607/student_retention_in_higher_ed.aspx>

⁶⁰ Although not raised by anyone at Coventry.

"a fairly good working knowledge of XHTML, CSS and in particular PHP and Object Orientated programming – some experience with WordPress is also required."

Students on courses which did not cover all these particular technologies would not feel able to apply, even though they may be experienced in something equivalent. Whilst there seem to be fewer advertisements which are quite so specific than there were decades ago, they have the effect of excluding some candidates who, with some training, would be excellent.

The IT industry uses a vast range of technologies and, even if resources were not limited, universities can only ever expose their students to a tiny proportion of even the most common ones. In order to open themselves to candidates who may be very appropriate over the longer-term, employers must try to be as flexible as possible in their recruitment, especially when considering the requirements of first-level graduate posts (Recommendation #20).

5.2 The unemployment conundrum

The poor level of computer graduate employment² over many years of reported IT skills shortage does merit concern and explanations have been sought. The CPHC⁶¹ identified that the profile of computing students is slanted in ways which correlate with weaker graduate employment (*i.e.* students who tend to be male, older, non-white, achieve poorer degree results and attend post-1992 universities) although their statistical analysis also identified that these factors do not fully explain the disparity in employment outcomes.

Blame is sometimes attributed directly and solely on, for example: *"poor quality training courses in universities and colleges... Many computer science courses are nothing more than 'sausage factories' "*⁶². This particular comment was based on the NESTA report⁴, despite the fact that that report was specifically looking at issues in the creative sphere, such as games degrees. However, whilst probably not meriting such a severe comment, it is likely to be the case that all degree courses, in any discipline, at any university, could be improved.

There thus seem to be a set of influences which together are leading to the current situation of both a skills shortage and elevated computing graduate unemployment (as shown in **Figure 1**).

⁶¹ CPHC (2012) *CS Graduate unemployment report 2012*. Council of Professors and Heads of Computing. [online] Available from http://cphcuk.files.wordpress.com/2013/12/cs_graduate_unemployment_report.pdf

⁶² Guardian (2012) 'Firms highlight UK's computer skills shortage'. *The Guardian*. 10 January 2012, 1-2

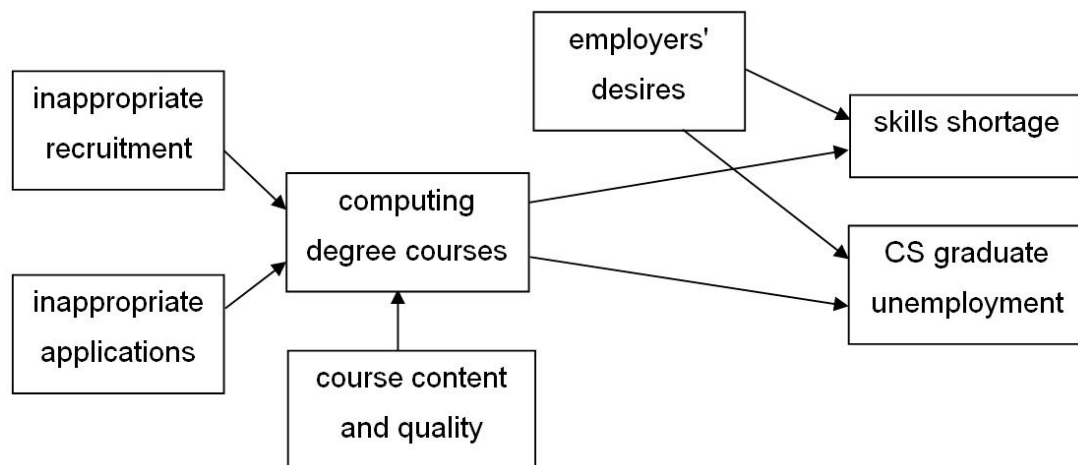


Figure 1: Influences on Computer Science skills shortage & graduate unemployment

- Some students are inappropriately recruited in that they do not have the ability or aptitude to cope with their degree. Many attempts have been made to identify aptitude tests which could screen computing applicants, although these have largely been unsuccessful.
- Some pupils apply inappropriately on a misperception of what computing is about or their specific course's content. Some of these young people will adjust to their course and thrive, whilst others will leave. However a number will remain on course, perhaps dissatisfied and barely engaged, maybe scraping through with a weak degree.
- Degree courses vary widely in how vocationally relevant they aim to be. Some deliberately focus on the theoretical underpinnings with the expectation that students can learn specific application as, and if, they later require it. Designers of all computing degrees need to make a judgement on this balance.
- Some computing degrees are highly specialized and often aim at a specific field of employment, such as Games Programming. However degrees with generalist titles also vary widely in breadth and depth.
- Computing degrees can only ever expose students to a limited range of technologies, restricted by time, staff expertise and resource availability. Additionally of course the wider the students' exposure the weaker their expertise will be in any specific technology.
- Employers can be very specific in their recruitment desires. Sometimes they specify precisely which technologies candidates must be skilled in, with no allowance for any alternatives in which some potential candidates may have expertise. This can make securing the first graduate job difficult for some.
- Employers sometimes comment that candidates have inadequate skills in other regards, such as written English or inter-personal or professional skills. Whilst acknowledging this as a problem, no evidence of it arose in the current project.

6. RECOMMENDATIONS

BCS (and other professional bodies), perhaps working in conjunction with CAS and eSkillsUK:

1. Both this project and the literature indicate that there is a need to change the public image of computing and the IT profession. It may help if there were activities and publicity, aimed at the general public, describing some computing successes, which give some indication of the intellectual processes and the people behind them. This should raise the profile of the profession; give a sense of the wide range of tasks and activities involved and confront the image of the 'geek', by presenting IT professionals as personable, effective human beings. Cost-effective, broad distribution channels would be needed. It might be worth investigating the effectiveness of creating a series of light-hearted YouTube videos, released through social media, perhaps linked to some television exposure. It might be useful if some of this material were aimed at pre-teens, in order to influence them before negative stereotypes impact. It might be worth considering generating these, or at least ideas for these, through a Student Competition. (See §2.1 and 2.2).

2. It may be worth investigating if there is a need for resources such as a magazine for school careers teachers and advisors, covering opportunities and job roles. Something with similar content for teachers could be disseminated, maybe via TESConnect. A magazine could perhaps be modelled on CS4FN (2013), aimed at young people, which presents applications of computing. (See §2.2 and 2.3).

University Lecturers and Course Leaders

3. Most lecturers probably already try to make their teaching relevant and interesting. However, this research showed that students are not always clear why they are being asked to master some aspects of their course, typically mathematics. Understanding the relevance of material is important for student engagement. Hence, particularly for more challenging or theoretical topics, it is important that students understand the relevance of material: how they might use it on their course or later. (See §4.4).

4. To support students in their learning, all courses should ensure they engender a learning community, one which is accepting of all students and generates a sense of belonging in students. The literature suggests that staff need to relate to students on a human level, although as mentors rather than friends. Someone should care about the progress and general circumstance of each student. (See §4.4).

5. Some students are surprised by elements of course content. Whilst this research found that many students undertake very little investigation into the content of the courses for which they apply, course information should provide enough detail to applicants, maybe via a website, such that diligent applicants are

not surprised by substantial aspects of course content. Although there is some commercial sensitivity associated, it may assist some applicants if more than a list of module titles were available. (See §4.2).

6. Some new entrants struggle with the mathematics, even on courses which are not mathematics-focussed. Many students arrive with only a GCSE Grade 'C', or equivalent. It may be worth investigating if those are the students who really struggle and if raising the entry requirement to Grade 'B' would be helpful. Alternatively it may be useful to consider developing something like a short, pre-session, online mathematics revision course for those candidates who have only a Grade 'C', the passing of which could be a condition of admission. (See §4.1).

7. Many participants expressed enthusiasm for the opportunity to exercise their imagination. Hence course designers could consider if they can exploit this enthusiasm by building flexibility into their assessments, whilst still bounding tasks with clear assessment criteria. (See §4.3).

8. As this research made clear, many students, even those enrolled on computing courses, know very little about the computing employment market and job opportunities. Whilst students have opportunities to talk to employers during visits and so forth some students' lack of knowledge can be profound. Students should be aware of a wide range of types of IT employment opportunities so they can decide what might interest them and suit their skills. Approaches which could be considered include talks from recent graduates, which might help, especially if they talk about employment issues generally and not just their personal career routes. (See §2.2).

9. There may be benefit to be gained by considering if greater attention could be paid during the recruitment process to ensure that applicants are aware of the nature of the course for which they are applying. Whilst their understanding may be evident from their personal statement, in many cases it will not be. It cannot be assumed that the person providing the reference is well-informed either. When the revised National Curriculum is fully embedded it might be safer to assume that applicants understand the nature of the subject, but that is some years away. To achieve this assurance it may be necessary to interview all applicants. This is labour intensive and it seems that most universities do not currently do this but it might lead to long-term dividends in the form of enrolling students who are more interested and successful, even if overall recruitment is diminished. (See §4.2).

10. Courses need to be designed with employment in mind. Some CS courses may aim to teach theory to the depth needed for subsequent research work but most courses take a more vocational view and aim for industrial relevance, whilst still covering the necessary underpinning theoretical material. This was raised as an issue at some institutions, although not by participants at Coventry. There seems to be no reason why a CS course for high-achieving students should not be very theoretical, provided those students also acquire the practical skills necessary for relevant target employment. (See §5.1).

11. Course leaders may wish to consider how they encourage student engagement and the approaches they adopt when addressing apparent dis-

engagement. The view of engagement presented earlier, although tentative, may be useful in developing supportive approaches. (See §4.4).

University management

12. To ensure that the students recruited all have a real interest in their course (whether their motivation is intrinsic or extrinsic), universities need to be confident in their judgements and reject any applicants who they believe have significantly misunderstood the nature and qualities of the subject. This is not easily done if the student is academically quite strong. Whilst the immediate incentives can sometimes be to accept all plausible applicants this can lead to long term costs and problems, some of which are hidden or unquantifiable. (See §4.2).

13. Some participants were very clear that they want, and for their employment prospects they believe that they need, skills in the most current technologies. Whilst raised as a problem in this research, although not by any Coventry participants, universities need to ensure that computing students have access to reasonably up-to-date and industrially-relevant facilities on which to learn their craft. Computing students need access to some specialist facilities so a standard university PC and software image is likely to be too restrictive. Open source and free software can be used for some learning, as can old or less common packages. Nonetheless for most students it is important to know they have some skills which will be of use to employers both so they feel that they have agency to apply for advertised vacancies and so they have the confidence to 'sell' themselves in interviews. (See §5.1).

14. To avoid the demotivating effect of being required to study inappropriate content, courses should allow students to build upon their existing skills. In particular students should not have to take modules which are a long way below their current capability. At Coventry University, and probably elsewhere, this maybe could be addressed through the use of the Accreditation of Prior Learning (APL) scheme, perhaps by ensuring students' creditworthiness using a start-of-module assessment, and accredited students being encouraged to take a replacement module. Alternatively, a scheme with explicit multiple entry points could be derived. At Coventry and perhaps elsewhere, such arrangements might be disruptive to the move to course-focussed teaching and assessment and the latter may not be permitted by Coventry's regulations. However, Coventry's move to project-based learning may mitigate the problem for some of the affected students, allowing them to operate 'as expert' in their teams. (See §4.4).

Governmental agencies: Department for Business, Innovation and Skills (BIS), Department for Education (DfE), Teaching Agency

15. This research, and the literature, indicates that there is a need to increase the visibility and potential appeal of computing. To this end, it would be helpful if consideration was given to extending STEM (Science, Technology, Engineering

and Mathematics) initiatives to explicitly embrace computing and IT, other than when there is an overwhelming reason not to do so. This would support computing in raising its profile and enhance its recruitment opportunities through the various STEM initiatives. Additionally, it may be helpful if computing was clearly identified in STEM activities. For clarity, when the acronym STEM is 'decoded', computing should be explicitly identified as being embraced, perhaps as part of 'technology'. For information aimed at the general public this is not an issue since they probably already presume STEM includes computing. However schools and universities are very familiar with examples of STEM activities where computing is excluded. (See §2.3).

16. Since there is a need for many more computing teachers in schools, the recent funding for scholarships and bursaries for training new computing teachers should remain in place long term. These will help attract graduates into teaching. (See §3.2).

17. Introducing the revised Computing National Curriculum into schools will require large numbers of additional skilled or retrained computing teachers. It will be some years before they are available in adequate numbers. Hence it may be useful to consider delaying the statutory requirement to comply with the revised curriculum for a period of, say 2 years, to allow time for more teachers to be trained or retrained. This may allow the curriculum's smoother, more effective introduction. (See §3.2).

Schools/Local Education Authorities

18. School Heads and local education authorities need to consider how they will meet the requirements of the revised National Curriculum. However, since it substantially differs from the previous ICT curriculum, for the Computing curriculum they will need particularly to consider the availability of appropriate staff expertise. This applies to the secondary sector but also to primary where it may prove particularly challenging since almost all teachers work across the curriculum. (See §3.2).

Careers staff

19. Some participants were clear that careers staff did not necessarily have an accurate view of the nature of computing. Careers staff, including relevant school teachers, need to be aware of the nature of IT employment and the skills required. In particular the range of job roles in the industry needs to be clear. If suitable materials were available (Recommendations #1 and #2), it may help achieve this. (See §2.2 and 2.3).

IT employers (via Intellect and eSkillsUK)

20. Some portion of the skills gap in IT must be attributable to the inflexibility of some employers' recruitment requirements. To assist with providing graduates with employment opportunities and to help with skills development and availability in the sector generally, employers need to be as flexible as possible in their advertising and recruitment of staff, particularly first-level graduate jobs. (See §5.1).

Acknowledgement

This report is based on a PhD thesis which is available to readers¹¹. The research project was supported by a scholarship, awarded by Coventry University.

Author Biography

Lisa Payne spent some years early in her career working in the IT industry. Later, she spent over 25 years as a Computer Science lecturer, mostly at Coventry University, latterly as a Principal Lecturer. The '*Why Computing?*' project was undertaken during a period when she was a full-time PhD research student, part-time lecturer and an Honorary Lecturer. Lisa remains an Honorary Lecturer, in the Department of Computing at Coventry University.